Movements of Gastrointestinal Tract

■ MASTICATION

Mastication or **chewing** is the first mechanical process in the gastrointestinal (GI) tract, by which the food substances are torn or cut into small particles and crushed or ground into a soft **bolus.**

Significances of mastication

1. Breakdown of foodstuffs into smaller particles
2. Mixing of saliva with food substances thoroughly
3. Lubrication and moistening of dry food by saliva, so that the bolus can be easily swallowed
4. Appreciation of taste of the food.

■ MUSCLES AND THE MOVEMENTS OF MASTICATION

Muscles of Mastication

1. Masseter muscle
2. Temporal muscle
3. Pterygoid muscles
4. Buccinator muscle.

Movements of Mastication

1. Opening and closure of mouth
2. Rotational movements of jaw
3. Protraction and retraction of jaw.

■ CONTROL OF MASTICATION

Action of mastication is mostly a reflex process. It is carried out voluntarily also. The center for mastication is situated in medulla and cerebral cortex. Muscles of mastication are supplied by mandibular division of 5th cranial (trigeminal) nerve.

■ DEGLUTITION

Definition

Deglutition or swallowing is the process by which food moves from mouth into stomach.

Stages of Deglutition

Deglutition occurs in three stages:

I. Oral stage, when food moves from mouth to pharynx
II. Pharyngeal stage, when food moves from pharynx to esophagus
III. Esophageal stage, when food moves from esophagus to stomach.

■ MOVEMENTS OF STOMACH

Activities of smooth muscles of stomach increase during gastric digestion (when stomach is filled with food) and when the stomach is empty.

Types of movements in stomach

1. Hunger contractions
2. Receptive relaxation
3. Peristalsis.

■ 1. HUNGER CONTRACTIONS

Hunger contractions are the movements of empty stomach. These contractions are related to the sensations of hunger.

Hunger contractions are the peristaltic waves superimposed over the contractions of gastric smooth muscle as a whole. This type of peristaltic waves is different from the digestive peristaltic contractions. The digestive peristaltic contractions usually occur in body and pyloric parts of the stomach. But, peristaltic contractions of empty stomach involve the entire stomach. Hunger contractions are of three types:

Type I Hunger Contractions

Type I hunger contractions are the first contractions to appear in the empty stomach, when the tone of the gastric muscles is low. Each contraction lasts for about 20 seconds. The interval between contractions is about 3 to 4 seconds. Tone of the muscles does not increase between contractions. Pressure produced by these contractions is about 5 cm of H_2O.

Type II Hunger Contractions

Type II hunger contractions appear when the tone of stomach is stronger. Tone increases in stomach if food intake is postponed, even after the appearance of the type I contractions. Each of the type II contractions lasts for 20 seconds like type I contractions. But the pause between the contractions is decreased. Pressure produced by these contractions is 10 to 15 cm of H_2O.

Type III Hunger Contractions

Type III hunger contractions are like incomplete tetanus. These contractions appear when the hunger becomes severe and the tone increases to a great extent. Type III hunger contractions are rare in man as the food is taken usually before the appearance of these contractions. These contractions last for 1 to 5 minutes. The pressure produced by these contractions increases to 10 to 20 cm of H_2O.

When the stomach is empty, the type I contractions occur first, followed by type II contractions. If food intake is still postponed, then type III contractions appear and as soon as food is consumed, hunger contractions disappear.

■ 2. RECEPTIVE RELAXATION

Receptive relaxation is the relaxation of the upper portion of the stomach when bolus enters the stomach from esophagus. It involves the fundus and upper part of the body of stomach. Its significance is to accommodate the food easily, without much increase in pressure inside the stomach. This process is called **accommodation** of stomach.

■ 3. PERISTALSIS

When food enters the stomach, the peristaltic contraction or peristaltic wave appears with a frequency of 3 per minute. It starts from the lower part of the body of stomach, passes through the pylorus till the **pyloric sphincter.**

Initially, the contraction appears as a slight indentation on the greater and lesser curvatures and travels towards pylorus. The contraction becomes deeper while traveling. Finally, it ends with the constriction of pyloric sphincter. Some of the waves disappear before reaching the sphincter. Each peristaltic wave takes about one minute to travel from the point of origin to the point of ending.

This type of peristaltic contraction is called **digestive peristalsis** because it is responsible for the grinding of food particles and mixing them with gastric juice for digestive activities.

■ FILLING AND EMPTYING OF STOMACH

■ FILLING OF STOMACH

While taking food, it arranges itself in the stomach in different layers. The first eaten food is placed against the greater curvature in the fundus and body of the stomach. The successive layers of food particles lie nearer, the lesser curvature, until the last portion of food eaten lies near the upper end of lesser curvature, adjacent to cardiac sphincter.

The liquid remains near the lesser curvature and flows towards the pyloric end of the stomach along a V-shaped groove. This groove is formed by the smooth muscle and it is called **magenstrasse.** But, if a large quantity of fluid is taken, it flows around the entire food mass and is distributed over the interior part of stomach, between wall of the stomach and food mass.

■ EMPTYING OF STOMACH

Gastric emptying is the process by which the chyme from stomach is emptied into intestine. Food that is swallowed enters the stomach and remains there for about 3 hours. During this period, digestion takes place. Partly digested food in stomach becomes the chyme.

Chyme

Chyme is the semisolid mass of partially digested food that is formed in the stomach. It is acidic in nature. Acid chyme is emptied from stomach into the intestine slowly, with the help of peristaltic contractions. It takes about 3 to 4 hours for emptying of the chyme. This slow emptying is necessary to facilitate the final digestion and maximum (about 80%) absorption of the digested food materials from small intestine. Gastric emptying occurs due to the peristaltic waves in the body and pyloric part of the stomach and simultaneous relaxation of pyloric sphincter.

■ MOVEMENTS OF SMALL INTESTINE

Movements of small intestine are essential for mixing the chyme with digestive juices, propulsion of food and absorption.

Types of Movements of Small Intestine

Movements of small intestine are of four types:

1. Mixing movements:
   i. Segmentation movements
   ii. Pendular movements.
2. Propulsive movements:
   i. Peristaltic movements
   ii. Peristaltic rush.
3. Peristalsis in fasting – migrating motor complex
4. Movements of villi.

■ 1. MIXING MOVEMENTS

Mixing movements of small intestine are responsible for proper mixing of chyme with digestive juices such as pancreatic juice, bile and intestinal juice. The mixing movements of small intestine are segmentation contractions and pendular movements.

i. *Segmentation Contractions*

Segmentation contractions are the common type of movements of small intestine, which occur regularly or irregularly, but in a rhythmic fashion. So, these movements are also called rhythmic segmentation contractions.

The contractions occur at regularly spaced intervals along a section of intestine. The segment of the intestine involved in each contraction is about 1 to 5 cm long. The segments of intestine in between the contracted segments are relaxed. The length of the relaxed segments is same as that of the contracted segments. These alternate segments of contraction and relaxation give appearance of rings, resembling the chain of sausages.

After sometime, the contracted segments are relaxed and the relaxed segments are contracted (Fig. 43.2). Therefore, the segmentation contractions **chop** the chyme many times. This helps in mixing of chyme with digestive juices.

ii. *Pendular Movement*

Pendular movement is the sweeping movement of small intestine, resembling the movements of **pendulum** of clock. Small portions of intestine (loops) sweep forward and backward or upward and downward. It is a type of mixing movement, noticed only by close observation.

It helps in mixing of chyme with digestive juices.

■ 2. PROPULSIVE MOVEMENTS

Propulsive movements are the movements of small intestine which push the chyme in the aboral direction through intestine. The propulsive movements are peristaltic movements and peristaltic rush.

i. *Peristaltic Movements*

Peristalsis is defined as the wave of contraction followed by wave of relaxation of muscle fibers. In GI tract, it always travels in aboral direction. Stimulation of smooth muscles of intestine initiates the peristalsis. It travels from point of stimulation in both directions. But under normal conditions, the progress of contraction in an oral direction is inhibited quickly and the contractions disappear. Only the contraction that travels in an aboral direction persists.

According to the law of intestine, the response of the intestine for a local stimulus consists of a contraction

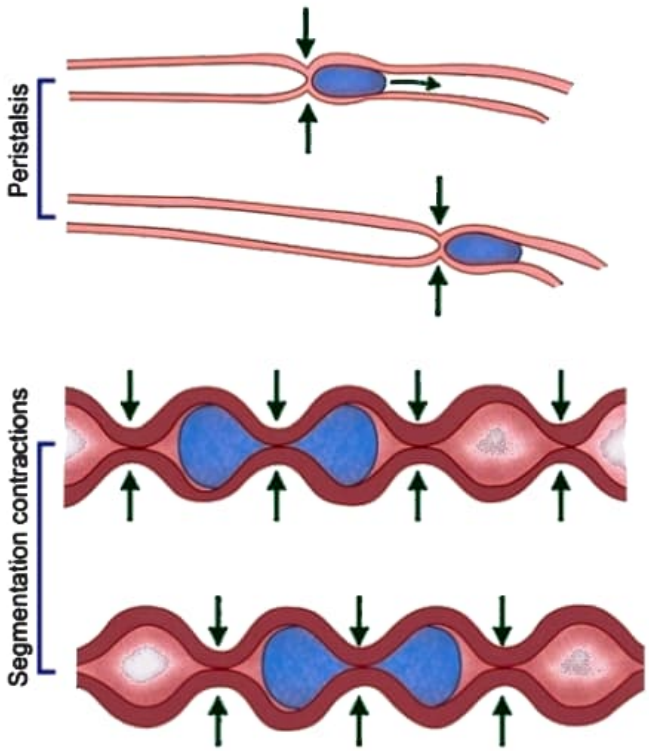


FIGURE 43.2: Movements of small intestine

of smooth muscle above and relaxation below the stimulated area.

Peristaltic contractions start at any part of the intestine and travel towards anal end, at a velocity of 1 to 2 cm/sec. The contractions are always weak and usually disappear after traveling for few centimeter. Because of this, the average movement of chyme through small intestine is very slow and the average velocity of movement of the chyme is less than 1 cm/sec. So, the chyme requires several hours to travel from duodenum to the end of small intestine.

Peristaltic waves in small intestine increase to a great extent immediately after a meal. This is because of **gastroenteric reflex,** which is initiated by the distention of stomach. Impulses for this reflex are transmitted from stomach along the wall of the intestine via myenteric plexus.

ii. *Peristaltic Rush*

Sometimes, the small intestine shows a powerful peristaltic contraction. It is caused by excessive irritation of intestinal mucosa or extreme distention of the intestine. This type of powerful contraction begins in duodenum and passes through entire length of small intestine and reaches the ileocecal valve within few minutes. This is called peristaltic rush or rush waves.

Peristaltic rush sweeps the contents of intestine into the colon. Thus, it relieves the small intestine off either irritants or excessive distention.

■ 3. PERISTALSIS IN FASTING – MIGRATING MOTOR COMPLEX

Migrating motor complex is a type of peristaltic contraction, which occurs in stomach and small intestine during the periods of fasting for several hours. It is also called **migrating myoelectric complex.** It is different from the regular peristalsis because, a large portion of stomach or intestine is involved in the contraction. The contraction extends to about 20 to 30 cm of stomach or intestine. This type of movement occurs once in every 1½ to 2 hours.

It starts as a moderately active peristalsis in the body of stomach and runs through the entire length of small intestine. It travels at a velocity of 6 to 12 cm/min. Thus, it takes about 10 minutes to reach the colon after taking origin from the stomach.

Significance of Peristalsis in Fasting

Migrating motor complex sweeps the excess digestive secretions into the colon and prevents the accumulation of the secretions in stomach and intestine. It also sweeps the residual indigested materials into colon.

■ 4. MOVEMENTS OF VILLI

Intestinal villi also show movements simultaneously along with intestinal movements. It is because of the extension of smooth muscle fibers of the intestinal wall into the villi.

Movements of villi are shortening and elongation, which occur alternatively and help in emptying lymph from the central lacteal into the lymphatic system. The surface area of villi is increased during elongation. This helps absorption of digested food particles from the lumen of intestine.

Movements of villi are caused by local nervous reflexes, which are initiated by the presence of chyme in small intestine. Hormone secreted from the small intestinal mucosa called **villikinin** is also believed to play an important role in increasing the movements of villi.

■ MOVEMENTS OF LARGE INTESTINE

Usually, the large intestine shows sluggish movements. Still, these movements are important for mixing, propulsive and absorptive functions.

Types of Movements of Large Intestine

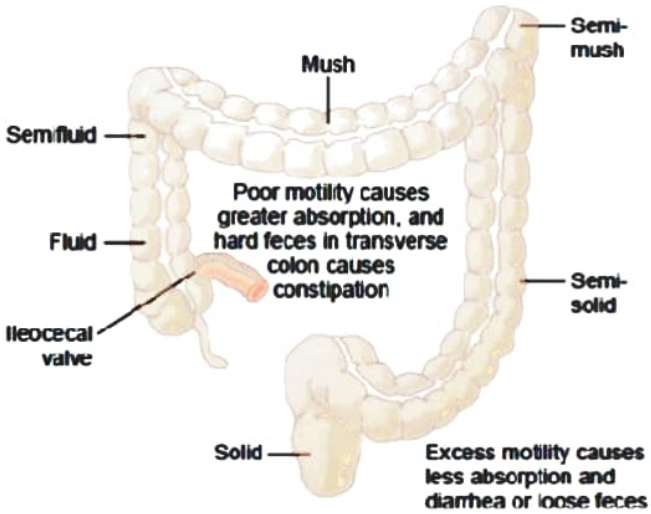
Movements of large intestine are of two types:

1. Mixing movements: Segmentation contractions
2. Propulsive movements: Mass peristalsis.

Movements of Large Intestine • Mixing movements (Haustrations) • Propulsive movements (Mass movements)

Haustrations

Haustrations • Large circular constrictions occur in the large intestine At each of these constrictions about 2. 5 cm of the circular muscle contracts • At the same time the longitudinal muscle of the colon, which is aggregated into three longitudinal strips called the teniae coli, contracts. These combined contractions of the circular and longitudinal strips of muscle cause the unstimulated portion of the large intestine to bulge outward into baglike sacs called haustrations.



• Each haustration usually reaches peak intensity in about 30 seconds and then disappears during the next 60 seconds.

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• After another few minutes, new haustral contractions occur in other areas nearby

Mass Movements • These movements usually occur only one to three times each day • A mass movement is a modified type of peristalsis

• First a constrictive ring occurs in response to distension • Then rapidly the 20 or more cm of colon distal to the constrictive ring lose their haustrations and instead contract as a unit propelling the fecal material further down the colon. • The contraction develops progressively more force for about 30 seconds and relaxation occurs during the next 2 to 3 minutes. • Then another mass movement occurs. • A series of mass movements usually persists for 10 to 30 minutes. Then they cease but return perhaps a half day later. • When they have forced a mass of feces into the rectum the desire for defecation is felt

• Irritation in the colon can also initiate intense mass movements • Appearance of mass movements after meals is facilitated by gastrocolic and duodenocolic reflexes. • These reflexes result from distention of the stomach and duodenum.

Defecation

- The process by which faeces are emptied from the rectum through the anus.

Defecation Reflex

1. Distension of the rectum.
2. Stimulation of the stretch receptors in the rectum.
3. A. Short reflex: Stimulation of myenteric plexus in sigmoid colon and rectum.

   B. long reflex: stimulation of parasympathetic motor neurons in sacral spinal cord.

   C. stimulation of somatic motor neurons.
4. Increased local peristalsis. Relaxation of internal anal sphincter and contraction of external anal sphincter.